

# Kshitij Goel

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## Research Overview

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My research aims to create teams of robots that can adapt their agency and knowledge with environmental complexity while operating near their sensing, compute, and physical limits. To this end, I design efficient on-device algorithms, spatially-scalable data structures, and tractable probabilistic reasoning methods.

## Education

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**Ph.D. in Robotics**, *Carnegie Mellon University (CMU)* Aug. 2021 – Present

Thesis: *Self-Organizing Gaussian Mixture Models for Active Multi-Robot Reconstruction*

Advisor: [Wennie Tabib](#)

Committee: [Wennie Tabib](#), [David Wettergreen](#), [Sebastian Scherer](#), [Kostas Alexis](#), [Nathan Michael](#)

Future Faculty Program Participant, Eberly Center for Teaching Excellence and Educational Innovation

**M.S. in Robotics (Research)**, *Carnegie Mellon University (CMU)* Aug. 2019 – Jul. 2021

Thesis: *Rapid Subsurface Exploration with Multiple Aerial Robots*

Advisor: [Nathan Michael](#)

Committee: [Nathan Michael](#), [Wennie Tabib](#), [David Wettergreen](#), [Paloma Sodhi](#)

**B.Tech. (Honors) in Aerospace Eng.**, *Indian Institute of Technology Kharagpur* May 2013 – May 2017

Thesis: *Reconfigurable Control for Damaged Fighter Aircraft*

Advisor: [Manoranjan Sinha](#)

## Employment

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**Graduate Research Assistant**, *CMU* (Advisor: [Wennie Tabib](#)) Aug. 2019 – Present

**Research Assistant**, *CMU* (Advisor: [Nathan Michael](#)) Aug. 2017 – Jul. 2019

**Robotics Institute Summer Scholar (RISS)**, *CMU* (Advisor: [Nathan Michael](#)) Jun. 2017 – Jul. 2017

**Research Intern**, *CMU* (Advisor: [Nathan Michael](#)) May 2016 – Jul. 2016

**Research Intern**, *IIT Kanpur* (Advisor: [Abhishek](#)) May 2015 – Jul. 2015

**Research Assistant**, *IIT Kharagpur* (Advisors: [Bijoy Mukherjee](#), [Manoranjan Sinha](#)) Jan. 2015 – Apr. 2017

## Awards and Honors

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[Alan J. Perlis SCS Graduate Student Teaching Award](#) 2024

*For outstanding work in redesigning and teaching Mobile Robot Algorithms Laboratory, general excellence in teaching and student interaction, and dedication towards improving all courses he TA'd for.*

**Presidential Fellowship** 2023

One year fellowship towards PhD degree at CMU awarded by the CMU President and endowed by Uber Inc.

**King-Sun Fu Memorial Best Paper Award Honorable Mention** 2023

IEEE Transactions on Robotics (T-RO). Out of more than 200 accepted papers.

**Best Paper Award** 2022

Best paper at IEEE SSR 2022. Out of 56 accepted papers.

**National Science Foundation (NSF) Ph.D. Student Travel Award** 2021

To attend the ISER conference and participate in the Doctoral Consortium.

**FICCI Fellow, Robotics Institute Summer Scholars (RISS) program** 2017

Amongst 5 out of 800 candidates.

**Boeing-IIT Kharagpur University Relations Fellow** 2015 – 2017

For best all-round performance in Aerospace Engineering, IIT Kharagpur. Amongst 2 out of 50 candidates.

## Publications [Google Scholar; 231+ citations, h-index: 7+]

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Peer-reviewed lead-author publications are highlighted.

### Journal Articles

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- J5. **Kshitij Goel** and Wennie Tabib. *Distance and Collision Probability Estimation from Gaussian Surface Models*. IEEE Robotics and Automation Letters 2024. (Under Review)
- J4. **Kshitij Goel** and Wennie Tabib. *Incremental Multimodal Surface Mapping via Self-Organizing Gaussian Mixture Models*. IEEE Robotics and Automation Letters (RAL) 2023. Presentation at ICRA 2024, Yokohama, Japan Impact Factor: 5.2
- J3. **Kshitij Goel**, Nathan Michael, and Wennie Tabib. *Probabilistic Point Cloud Modeling via Self-Organizing Gaussian Mixture Models*. IEEE Robotics and Automation Letters (RAL) 2023. [video] Presentation at IROS 2023, Detroit, MI, USA Impact Factor: 5.2
- J2. Wennie Tabib, **Kshitij Goel**, John Yao, Curtis Boirum, and Nathan Michael. *Autonomous Cave Surveying With an Aerial Robot*. IEEE Transactions on Robotics (T-RO) 2021. [video] King-Sun Fu Memorial Best Paper Award Honorable Mention Impact Factor: 7.8
- J1. Micah Corah, Cormac O'Meadhra, **Kshitij Goel**, and Nathan Michael. *Communication-Efficient Planning and Mapping for Multi-Robot Exploration in Large Environments*. IEEE Robotics and Automation Letters (RAL) 2019. [video] Presentation at ICRA 2019, Montreal, Canada Impact Factor: 5.2

### Conference Publications

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- C8. Wennie Tabib, John Stecklein, Caleb McDowell, **Kshitij Goel**, Felix Jonathan, Abhishek Rathod, Meghan Kokoski, Edsel Burkholder II, Brian Wallace, Luis Ernesto Navarro-Serment, Nikhil Angad Bakshi, Tejus Gupta, Norman Papernick, David Guttendorf, Erik E. Kahn, Jessica Kasemer, Jesse Holdaway, and Jeff Schneider. *Decentralized Uncertainty-Aware Active Search with a Team of Aerial Robots*. IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR) 2024. (Under Review)
- C7. **Kshitij Goel** and Wennie Tabib. *GIRA: Gaussian Mixture Models for Inference and Robot Autonomy*. IEEE International Conference on Robotics and Automation (ICRA) 2024. [code] Acceptance Rate: 44.83%
- C6. **Kshitij Goel**, Yves Georgy Daoud, Nathan Michael, and Wennie Tabib. *Hierarchical Collision Avoidance for Adaptive-Speed Multirotor Teleoperation*. IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR) 2022. [video] Best Paper Award
- C5. Yves Georgy Daoud, **Kshitij Goel**, Nathan Michael, and Wennie Tabib. *Collaborative Human-Robot Exploration via Implicit Coordination*. IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR) 2022. [video]
- C4. **Kshitij Goel**, Micah Corah, Curtis Boirum, and Nathan Michael. *Fast Exploration Using Multirotors: Analysis, Planning, and Experimentation*. Field and Service Robotics (FSR) 2021. [video]
- C3. **Kshitij Goel**, Wennie Tabib, and Nathan Michael. *Rapid and High-Fidelity Subsurface Exploration with Multiple Aerial Robots*. International Symposium on Experimental Robotics (ISER) 2021. [video]
- C2. Wennie Tabib, **Kshitij Goel**, John Yao, Mosam Dabhi, Curtis Boirum, and Nathan Michael. *Real-Time Information-Theoretic Exploration with Gaussian Mixture Model Maps*. Robotics: Science and Systems (RSS) 2019. [video] Acceptance Rate: 31%

- C1. Alex Spitzer, Xuning Yang, John Yao, Aditya Dhawale, **Kshitij Goel**, Mosam Dabhi, Matt Collins, Curtis Boirum, and Nathan Michael. *Fast and Agile Vision-Based Flight with Teleoperation and Collision Avoidance on a Multirotor*. International Symposium on Experimental Robotics (ISER) 2018. [video]

## Theses

- T2. **Kshitij Goel**. *Rapid Subsurface Exploration with Multiple Aerial Robots*. MS Thesis, Carnegie Mellon University 2021. [talk]
- T1. **Kshitij Goel**. *Reconfigurable Control for Damaged Fighter Aircraft*. BTech Thesis, Indian Institute of Technology Kharagpur 2017. **Best Undergraduate Thesis in Aerospace Engineering Nomination**

## Reports

- R1. **Kshitij Goel**, Micah Corah, and Nathan Michael. *Fast Exploration Using Multirotors: Analysis, Planning, and Experimentation*. Technical Report CMU-RI-TR-19-03, Carnegie Mellon University 2019.

## Teaching

Mobile Robot Algorithms Laboratory (CMU 16-362), Co-Instructor with Prof. Wennie Tabib Fall 2023

Designed learning objectives. Wrote an initial draft of the course syllabus. Created and delivered 11 out of 22 lectures. Created presentation materials and two lab assignments from scratch. Average one to two hours per week in office hours. Coordinated two guest lectures. Applied the pedagogical skills learnt during the Eberly Future Faculty program.

Computer Vision (CMU 16-720, Prof. Deva Ramanan), Teaching Assistant Fall 2022  
 Statistical Techniques in Robotics (CMU 16-831, Prof. Kris Kitani), Teaching Assistant Spring 2022

## Mentoring

Jonathan Lee MS in Robotics (Research) at RI, CMU 2023 – Present  
 Akshay Chekuri Integrated BS/MS in ECE, CMU (Now at Shield AI) 2022 – 2024  
 Rohan Dhesikan Integrated BS/MS in ECE, CMU (Now at Tesla Autopilot) 2022 – 2023  
 Yves Georgy Daoud MS in Robotics (Research) at RI, CMU (Now at Agility Robotics) 2021 – 2022

## Academic Service

### Organizing Committee

GIRA: Gaussian Mixture Models for Inference and Robot Autonomy (RSS 2023 Workshop) 2023  
 Robotics Institute Summer Scholars (RISS) 2018

### Thesis Committee

David Russell, MS in Robotics (Research) at RI, CMU 2022 – 2023

### Reviewing

Autonomous Robots 2024 – Present  
 IEEE Robotics and Automation Letters (RAL) 2018 – Present  
 IEEE International Conference on Robotics and Automation (ICRA) 2018 – Present  
 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) 2020 – Present  
 International Symposium on Robotics Research (ISRR) 2022

## Community Service

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Pittsburgh Regional Science and Engineering Fair (Category Judge, Engineering and Robotics) 2024

Served as a judge at a large engineering and science fair organized by the Carnegie Science Center. Reviewed and provided feedback to 7th and 8th grade students on their projects.

National Service Scheme (Team Leader, Unit-9) 2013 – 2016

Promoted educational inclusiveness by leading a group of undergraduate students at IIT Kharagpur towards educating underprivileged children in the poor neighborhoods of the university.

## Skills

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Programming C, C++, Python

Frameworks Open3D, NumPy, SciPy, CUDA, pybind11, ROS, ROS2, PyTorch

Management JIRA, GitHub, Notion, Confluence

Exposition Affinity Designer, Affinity Photo, Final Cut Pro,  $\LaTeX$

## Selected Open-Source Software Contributions

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1. [gira3d/gira3d-reconstruction](#) | ★21 | *SOGMM-based Reconstruction System on CPU and GPU* 2023
2. [gira3d/sogmm\\_py](#) | ★1 | *Self-Organizing Gaussian Mixture Models (Python)* 2023
3. [gira3d/sogmm\\_open3d](#) | ★1 | *Self-Organizing Gaussian Mixture Models (CUDA C)* 2023
4. [gira3d/self\\_organizing\\_gmm](#) | ★1 | *Self-Organizing Gaussian Mixture Models (C++)* 2023

## Invited Talks

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1. *Introduction to Robotic Exploration (16-761 Mobile Robots, Invited Lecture)*, Carnegie Mellon University (CMU) 2024
2. *Fast Exploration using Multirotors*, Robotics Institute Summer Scholars (RISS) 2020